**International Journal of Agricultural Science and Research (IJASR)**
**ISSN(P): 2250-0057; ISSN(E): 2321-0087**
**Vol. 4, Issue 2, Apr 2014, 1-8**


# OSMOTIC REGULATION IN MANGO (*MANGIFERA INDICA L.)* CULTIVARS AT DIFFERENT PHENOLOGICAL STAGES OF FLOWERING AND FRUITING

**POOJA SAXENA[1], V. K. SINGH[2] & NEELAM PATHAK[3]**

[1,2]Central Institute for Subtropical Horticulture, Rehmankhera, Lucknow, Uttar Pradesh, India

[3]Integral University central, Lucknow, Uttar Pradesh, India

## ABSTRACT

Water stress in mango has been presumed to provide the stimulus for flowering, and is known as a successful signal for floral induction. Relative water content (RWC) and water potential (Ψw) are the most appropriate measure of plant water status in terms of the physiological consequence of cellular water deficit. The Ψw and RWC were evaluated in the leaves of 'Amrapali' (regular bearer) and 'Langra' (biennial bearer) cultivars under normal soil moisture condition (50-68%) of orchard (upto 60 cm depth) in order to know their osmotic adjustment capacity at critical stage of flowering and fruit growth. In the field condition Ψw and RWC in Amrapali was -6.0 MPa & 78.0%, -7.29 MPa & 74.9 % and -8.7 MPa & 61.85% at pre flower bud differentiation, flower bud differentiation and panicle elongation stage respectively whereas these values were -5.11 MPa & 75.41%, -7.32 MPa & 70.20% and -7.94 MPa & 55.23% in the corresponding stages of Langra cultivar. The osmotic adjustment calculated on the basis of difference of Ψπmorning (7:00-7:30 am) and Ψπhour (11:00-11:30 am) indicates that the Amrapali had higher osmotic adjustment capacity (11-31%) than Langra (10-30%) during critical stage of flowering. Relation of fruit drop and osmotic adjustment was also worked and Langra has more fruit drop (35-40%) counted at marble stage of fruit growth than the Amrapali (10-15%). These studies showed that Amrapali has more efficient mechanism for avoiding water loss than Langra cultivar.

**KEYWORDS:** Mango (*Mangifera indica* L.), Amrapali, Langra, Flower Bud Differentiation, Fruit Development, Osmotic Regulation

**Abbreviations:** Relative Water Content (RWC), Water Potential (Ψw), Osmotic Adjustment (AΔΨπ), Osmotic Potential (Ψπ), Turgor Potential ($\Psi_\infty$), Leaf Water Content (LWC)

## INTRODUCTION

Osmotic adjustment (AΔΨπ), is a process of accumulation of compatible solute (Girma and Krieg, 1992), allows plants to tolerate temporary or prolonged periods of water shortage and is one of the crucial mechanism involved in plant adaptation under water deficit (Chaves et al., 2003). Plants under water deficits may synthesize and accumulate high concentrations of compatible solutes like amino acids (proline and aspartic acid), proteins, sugars and organic acids (Ingram and Bartels, 1996; Chartzoulakis et al., 1999) which contribute to lowering the osmotic potential (Ψπ) during stress condition and allow available water to move into the cells, thereby maintaining the desired turgor potential (Ψp) and increasing tissue tolerance to low soil water potentials (Bartolomeo et al., 2005).These solutes may also sequester water molecules, protect cell membranes and protein complexes and allow the metabolic machinery to continue functioning. Plant water stress has been presumed to provide the stimulus for flowering (Davenport, 2007). Cool temperature upregulates the flowering in mango however in the absence of cool temperatures, induction of flowering occur in response to water stress and different degree of water stress during flower bud development is advantageous for good flowering (Singh and Singh,2003). Furthermore, it has been demonstrated that the floral stimulus originates from mature leaves in

mango and young leaves inhibit the floral bud initiation (Kulkarni, 1988). Hence water stress during flower bud development in subtropical condition restricts the production of new leaves and consequently increases the proportion of flower inductive leaves (mature leaves). There is possibility that floral induction in mango can also occur after a period of plant water stress in favorable temperature, when canopies consist mainly of mature, inductive leaves (Nunez-Elisea and Davenport, 1994). Osmotic adjustment is one of the important phenomenon under which cell maintain the required turgor pressure during active biological event like flowering and fruit development under natural stress. However to the best of our knowledge no such studies have been conducted in mango particularly under subtropical condition. Some fragmentary reports on the subject are available in apple (Lakso et al., 1984), citrus (Koch and Avigne, 1990), peach (Young et al., 1982), and grape (During, 1985).

The main effect of water stress on fruit growth according to the quantity of water shortage and the period when stress occurred was to alter the final mango size. Simmons et al. (1995) observed that if irrigation was cut off between first half of the growing period and fruit set, water stress occurred and affect the fruit growth rate and fruit size. However water shortage close to harvest did not affect fruit size. Altered fruit size may be due to reduced cell numbers and cell expansion during active phase of fruit growth. Reducing water availability to mango trees by managing irrigation is characterised by measurements of lower leaf water potential at predawn (Schaffer et al., 1994). It was reported that fruit drop increased on trees due to partial root zone drying (Singh et al, 2009), resulting in a reduction in the total number of fruits per tree. This relationship between fruit drop and water stress is consistent with the report of Hartung et al. (2002) who proposed that higher levels of ABA were synthesized in response to water stress involved in fruit abscission in the early stages of mango development (Schaffer et al., 1994). The present study was undertaken with objectives to compare the variation in Water Potential (Ψw), osmotic adjustment and fruit drop in response to natural water stress during flowering and fruit growth in mango cultivar Amrapali and Langra.

## MATERIALS AND METHODS

The present investigations were carried out with full bearing (15 years old) trees of 'Langra' (biennial bearing), and 'Amrapali' (regular bearing) cultivars of mango during year 2011 and 2012 at Central Institute for Subtropical Horticulture, Rehmankhera, Lucknow located at 26.54$^{o}$N Latitude, 80.45$^{o}$E Longitude and 127 m above mean sea level. The potential shoots (50 nos.) were tagged from each direction and fully matured leaves of twigs samples adjacent to apical meristem were collected from each direction for the studies. Sampling was done at different phenological stages of flowering viz. Pre Flower Bud differentiation, Flower Bud differentiation, Bud Burst, Panicle elongation and Full Bloom and fruit growth (Marble, egg and maturity) as per standard procedure (Rajan et al., 2011).

## PLANT WATER STATUS

The tree water status was determined by simultaneous measurements of water potential (Ψw) and leaf water content (LWC) in 5 fully expanded leaves from the selected tree. Each excised leaf was immediately put inside zip pouch for Ψw measurement. Water Potential Monitoring System (WP4 & WP4-T Dewpoint Meters, Decagon Devices) was used for determination of Leaf water potential (Turner, 1981). Preliminary experiments were carried out to find the minimum equilibration time required. After equilibration of sample a disc was taken from mid portion of leaf and Ψw was measured. Standard solution of known water potential (Ψw) was always run with samples and values corrected to a temperature of 25$^{o}$C.

All predawn (7:00-7:30 am) and midday (11:00-11:30 am) Ψw measurements were made with water potential measurement system. Values of LWC were determined as: LWC=100 (FM−DM)/ FM; Where FM is leaf fresh mass and

DM is leaf dry mass. Dry mass was determined after drying the leaf samples at 80 °C for 24 h. Values of LWC was expressed as relative water content (RWC) by determining FM, DM and saturated mass (SM); [RWC = (FM−DM)/ (SM−DM)]. The SM was determined in rehydrated leaves by immersing the petiole in distilled water in a beaker sealed with parafilm. Full rehydration was achieved with 5 h in complete darkness at room temperature.

## OSMOTIC ADJUSTMENT

The percentage osmotic adjustment at different phenological stages was calculated on the basis of difference, between estimated osmotic potential at Ψπ morning (7:00-7:30 am) and at Ψπ hour (11:00-11:30 am), Girma and Krieg, 1992) i.e. % Osmotic adjustment= [(Ψπ morning) – (Ψπ hour) x 100].

Five leaves per tree at different phonological stages were used for each determination and a mean of measurements was made on each sample.

## STATISTICAL ANALYSIS

The data were analysed statistically in randomized block design and critical difference at 5% level was calculated.

## RESULTS AND DISCUSSIONS

The data presented in table 1 clearly showed that Amrapali had lower water potential at all the stages of flowering than Langra except bud burst stage (Table1). However at critical stage of fruit growth (marble, egg and maturity) Amrapali showed higher water potential (-7.42, -5.94 and 6.63 MPa) than Langra (-6.49, -6.5 and -7.08 MPa) cultivar. The relative water content was declined with advancement of phenophase of flowering and fruit growth (Table 2.). The decline in RWC in the cultivars during different phenophase was paralleled by a substantial decrease in Ψw. Amrapali maintained high relative water content (70.10 %) at all stages of flower development even at highly stressed stage (flower bud burst) than % of Langra. Results of relative water content clearly revealed that Amrapali maintain high relative water content even at very low water potential (data not shown) as observed during critical stage of reproductive growth. This indicates that its tissue may have highly elastic in nature and have more water holding capacity. The value of osmotic adjustment substantiate the finding that Amrapali had higher osmotic regulation value than Langra at most of the phenophases of flowering and fruiting being maximum (18.0%) during flower bud differentiation and at fruit maturity (31.0%) and minimum at panicle elongation (11.0%) & marble stage (22.0%) of fruit growth (Table 3.).

Leaf water content during fruit growth stage (marble, egg and maturity) was also found higher in Amrapali (73.20-75.80%) than Langra (70.11-72.33%). This further show Amrapali had better osmotic adjustment capacity than Langra to regain its water status quickly after experiencing natural stress of flowering. Langra on the other hand showed lower water potential during these stages thus lower osmotic adjustment capacity may influence the fruits drop more in Langra, as reported earlier (Singh et al., 2009). The above findings clearly substantiate that Amrapali had more ability to transfer water from its tissues to the xylem sap, both under normal and natural stressed conditions, causes a greater lowering of Ψw compared with that observed in Langra, which results its greater osmotic regulation capacity.

Osmotic regulation is a key mechanism by which tree adapts to water shortages resulting from an increased solute concentration of cells in order to maintain the water potential gradients needed to ensure continued uptake of water during the natural stress period of flowering and fruit growth (Saxena et al., 2011). Osmotic adjustment in leaves and roots enabled plant growth during periods with low soil water availability (Jones et al., 1980 and Morgan, 1984). The greater lowering of cell Ψπ and more osmotic adjustment in Amrapali as indicated in results thus is responsible for a high Ψw gradient between leaves and roots, allowing the tree to extract water from the soil even at very low soil Ψw values

particularly during the period of flowering and fruit set. It is concluded that the better osmoregulation capacity may be associated with better flowering and fruiting performance with low fruit drop in Amrapali (regular bearer) than Langra cultivar of mango (*Mangifera indica* L.). The present study is also useful to decide the differential irrigation schedule at critical stage to enhance the flowering and reduce the fruit drops for more fruit yield particularly in low osmotic adjustment capacity cultivars Langra.

## ACKNOWLEDGEMENTS

Authors are thankful to Director, Central Institute for Subtropical Horticulture for providing laboratory facilities & encouragement and staff of Fruit Physiology laboratory for their cooperation during the study.

## REFERENCES

1. Bartolomeo Dichio, Cristos Xiloyannis, Adriano Sofo and Giuseppe Montanaro. (2005). Osmotic regulation in leaves and roots of olive trees during a water deficit and rewatering. Tree Physiology, 26, 179–185
2. Chartzoulakis K.A., Patakis and A.M. Bosabalidis. (1999). Change in water relations, photosynthesis and leaf anatomy induced by intermittent drought in two olive cultivars. Environ. Exp. Bot., 42, 113–120
3. Chaves M.M., J.P. Maroco and J.S. Pereira. (2003).Understanding plant responses to drought: from genes to the whole plant. Funct. Plant Biol., 30, 239–264
4. Davenport TL: Reproductive physiology of mango. (2007). *Braz.* J. Plant Physiol., 19 (4), 363-376.
5. During H. (1985). Osmotic adjustment in grapevines. Acta Hort., 171, 315-322
6. Girma, F.S. and D.R. Krieg. (1992). Osmotic adjustment in Sorghum. I. Mechanisms of diurnal osmotic potential changes. Plant Physiol., 99, 577–582
7. Hartung W, Sauter A, Hose E. (2002). Abscisic acid in the xylem: where does it come from, where does it go? J. Exp. Bot. 366, 27-32.
8. Ingram J. and D. Bartels. (1996). The molecular basis of dehydration tolerance in plants. Annu. Rev. Plant Physiol. Plant Mol. Biol., 47, 377–403.
9. Jones, M.M. and N.C. Turner. (1980). Osmotic adjustment in expanding and fully expanded leaves of sunflower in response to water deficits. Austral. J. Plant Physiol. 7:181-192.
10. Koch K.E. and W.T. Avigne. (1990). Postphloem, nonvascular transfer in citrus: Kinetics, metabolism, and sugar gradients. Plant Physiol., 93, 1405-1416
11. Kulkarni VJ. (1988b). Further studies on graft-induced offseason flowering and fruiting in mango (*Mangifera indica* L.). J. Hort. Sci., 63,361-367.
12. Lakso A.N., A.S. Geyer, and S.G. Carpenter. (1984). Seasonal osmotic relations in apple leaves of different ages. J. Amer. Soc. Hort. Sci., 109, 544-547
13. Morgan JM. (1984). Osmoregulation and water stress in higher plants. Annual Review of Plant Physiology 35, 299-319.
14. Núñez-Eliséa R, Davenport TL. (1994). Flowering of mango trees in containers as influenced by seasonal temperature and water stress. Sci. Hort. 58, 57-66

15. Saxena Pooja, Singh V. K. and Rajan S. (2011). Osmotic regulation in leaves of mango cultivars Amrapali and Langra during flowering- a stage of internal stress. In: Global Conference on Augmenting Production and utilization of Mango: Biotic and Abiotic Stresses. Central Institute for Subtropical Horticulture, Lucknow. Pp. 95

16. Rajan S., Tiwari Divya, Singh V.K., Saxena Pooja, Singh Shilpi, Reddy Y.T.N., Upreti, K.K., Burondkar M.M., Bhagwan A. and R. Kennedy. (2011). Application of extended BBCH scale for phenological studies in mango (*Mangifera indica* L.). Journal of Applied Horticulture, 13(2), 108-114

17. Schaffer B, Whiley AW, Crane JH. (1994). Mango. In: Schaffer B, Andersen PC (eds), CRC Handbook of Environmental Physiology of Fruit Crops, Subtropical and Tropical Crops, pp.165-197. CRC Press, Boca Raton.

18. Simmons SL, Hofman PJ, Hetherington SE. (1995). The effects of water stress on mango fruit quality. In: Proceedings of Mango 2000 marketing seminar and production workshop. Brisbane, Australia, pp.191-197

19. Singh V.K. and Singh Achal. (2003). Effect of paclobutrazol on Regularity of Bearing in mango (*Mangifera indica*). Physiol. Mol. Biol. Plants, 9 (2), 239-248

20. Singh V.K., Singh Gorakh, and Bhriguvanshi S.R. (2009). Effect of polyethylene mulch on soil nutrient level and root, leaf and fruiting characteristics of mango (*Mangifera indica*). Indian Journal of Agricurtural Sciences, 79 (6), 411-17.

21. Turner, N.C. (1981).Techniques and experimental approaches for the measurement of plant water status. Plant Soil, 58, 339–366

22. Young, E., Hand J.M. and Wiest S.C. (1982). Osmotic adjustment and stomatal conductance in Peach seedlings under severe water stress. Hort Science 17, 791-793

## APPENDICES

**Table 1: Water Potential (Ψ w) in Mango Cultivars**

| S. No. | Stages | Water Potential (Ψw MPa) | |
|---|---|---|---|
| | | Amrapali | Langra |
| 1. | Pre Flower Bud Differentiation | -6±0.45 | -5.11±0.15 |
| 2. | Flower Bud Differentiation | -6.44±0.26 | -5.87±0.17 |
| 3. | Bud Burst | -7.29±0.04 | -7.32±0.19 |
| 4. | Panicle elongation | -8.7±0.04 | -7.94±0.22 |
| 5. | Full Bloom | -7.39±0.29 | -6.91±0.52 |
| 6. | fruit Set (Marble stage) | -7.42±0.29 | -6.49±0.37 |
| 7. | Fruit Growth (egg stage) | -5.94±0.29 | -6.5±0.41 |
| 8. | Fruit Maturity (last week of May) | -6.63±0.41 | -7.08±0.12 |
| | **CD (p=0.05)** | **0.67** | **0.79** |

**Table 2: Relative Water Content (RWC) in Mango Cultivars**

| S. No. | Stages | Relative Water Content (%) | |
|---|---|---|---|
| | | Amrapali | Langra |
| 1. | Pre Flower Bud Differentiation | 78.00±1.20 | 75.41±2.22 |
| 2. | Flower Bud Differentiation | 74.90±1.44 | 70.20±1.89 |
| 3. | Bud Burst | 70.10±1.47 | 63.21±1.17 |
| 4. | Panicle elongation | 61.85±1.05 | 55.23±1.36 |
| 5. | Full Bloom | 71.00±1.39 | 67.41±1.47 |
| 6. | fruit Set (Marble stage) | 73.20±1.12 | 70.80±1.95 |
| 7. | Fruit Growth (egg stage) | 75.80±1.23 | 72.33±2.10 |
| 8. | Fruit Maturity (last week of May) | 73.21±1.56 | 70.11±1.44 |
| | **CD (p=0.05)** | **2.51** | **3.18** |

**Table 3: Osmotic Adjustment at Different Phenological Stages of Flowering and Fruiting in Mango (*Mangifera indica*) Cultivars**

| Stages | Osmotic Potential (Ψπ MPa) | | | | Osmotic Adjustment (AΔΨπ %) | |
|---|---|---|---|---|---|---|
| | Amrapali | | Langra | | | |
| | Ψπ Morning | Ψπ Hour | Ψπ Morning | Ψπ Hour | Amrapali | Langra |
| Pre flower bud differentiation | -6.1±0.1 | -6.2±0.05 | -5.9±0.02 | -6.0±0.33 | 15±0.18 | 11±0.6 |
| Flower Bud Differentiation | -6.5±0.05 | -6.7±0.1 | -6.3±0.4 | -6.4±0.44 | 18±0.55 | 12±1.04 |
| Bud Burst | -7.3±0.02 | -7.4±0.02 | -7.0±0.21 | -7.1±0.52 | 12±1.2 | 10±0.50 |
| Panicle elongation | -8.8±0.04 | -8.9±0.11 | -7.9±0.33 | -8.0±0.51 | 11±0.29 | 12±0.22 |
| Full Bloom | -7.4±0.12 | -7.6±0.21 | -7.0±0.41 | -7.1±0.42 | 15±0.91 | 14±1.10 |
| Fruit Set (Marble stage) | -7.5±0.22 | -7.7±0.22 | -6.5±0.55 | -6.7±0.12 | 22±1.05 | 19±1.05 |
| Fruit Growth (egg stage) | -5.9±0.32 | -6.3±0.04 | -6.5±0.41 | -6.8±0.44 | 29±0.6 | 24±1.01 |
| Fruit Maturity (last week of May) | -6.7±0.22 | -6.9±0.08 | -7.1±0.51 | -7.4±0.08 | 31±1.12 | 30±1.3 |
| **CD (p=0.05)** | **1.18** | **1.20** | **1.78** | **1.71** | **3.951** | **4.88** |

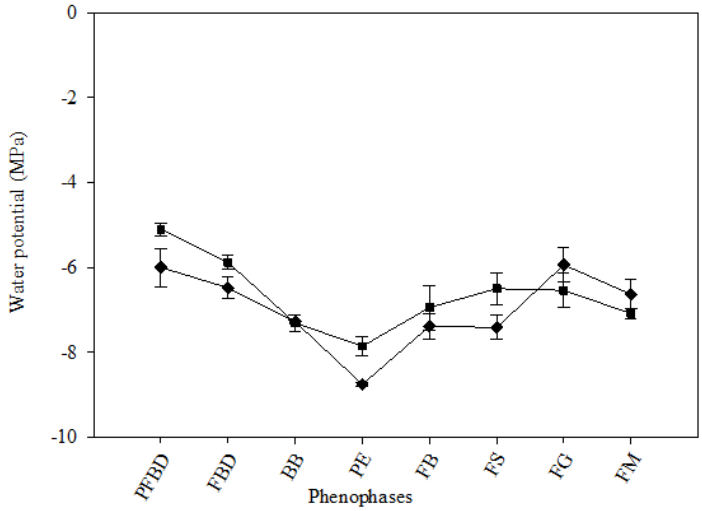


**Figure 1: Leaf Water Potential (Ψw) in Mango Cultivars Amrapali (◆—◆) and Langra (■ — ■) at Different Phenophases (PFBD= Pre Flower Bud Differentiation, FBD= Flower Bud Differentiation, BB= Bud Burst, PE=Panicle Elongation, FB=Full Bloom, FS=Fruit Set, FG=Fruit Growth, FM=Fruit Maturity)**

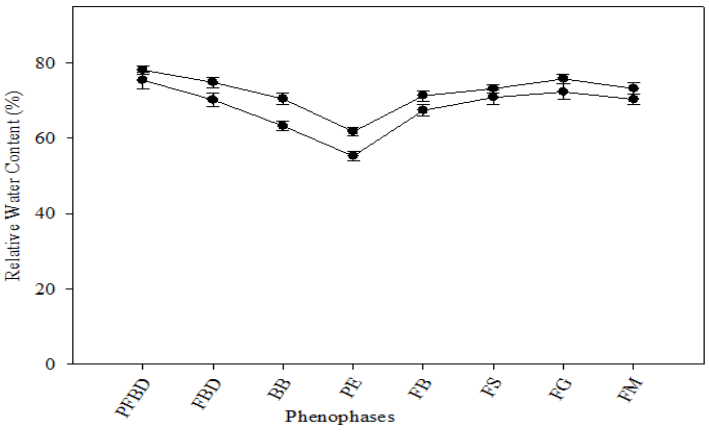


**Figure 2: Relative Water Content (RWC) in Mango Cultivars Amrapali (◆—◆) and Langra (■ — ■) at Different Phenophases (PFBD= Pre Flower Bud Differentiation, FBD= Flower Bud Differentiation, BB= Bud Burst, PE=Panicle Elongation, FB=Full Bloom, FS=Fruit Set, FG=Fruit Growth, FM=Fruit Maturity)**

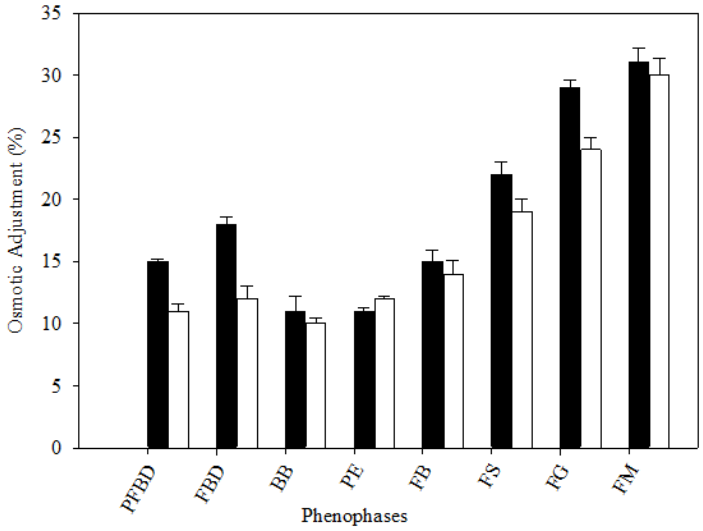


**Figure 3: Osmotic Adjustment (OA %) in Mango Cultivars Amrapali ( ■) and Langra ( □) at Different Phenophases (PFBD= Pre Flower Bud Differentiation, FBD=Flower Bud Differentiation, BB=Bud Burst, PE=Panicle Elongation, FB=Full Bloom, FS=Fruit Set, FG=Fruit Growth, FM=Fruit Maturity)**